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The Effects of Single-Sex Schooling on Student Achievement and Attitudes in Nigeria

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Single-sex schooling in Nigeria benefits female, but not male, math students. More research is needed to find out why — and why adolescent females in Nigeria do as well as adolescent males on math achievement tests (unlike their American counterparts).

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This study of Form Three (ninth-grade) students in Nigeria indicates that single-sex schools improve girls' achievement in mathematics and engender less stereotypic ideas about mathematics, even after extensive statistical adjustments for family background and school characteristics. But adolescent Nigerian males experience lower achievement and hold a more stereotypic view of mathematics under single-sex schooling, after similar statistical controls.

Many studies of the effects of single-sex education have shown that girls benefit more than boys, but only two studies in developing countries (this one and a study in Thailand) have found that boys' schools produce negative experiences. Therefore, it should not be concluded from this study that single-sex schooling is more beneficial to students than coeducation; instead, it seems particularly effective for females.

Why are there different responses? In part, differences between the types of students attending single-sex and coeducational schools may be responsible. Girls attending single-sex schools were more likely to have advantaged backgrounds, with more professionally employed fathers and more positive attitudes. They were younger and thus more likely to have progressed through school with few interruptions or repetitions. The girls in this sample (1,012 Form Three students in 40 government-owned schools, including four girls' schools and 16 boys' schools) also represented a very select group of students, since female secondary school attendance was very low in Nigeria in 1983 when the data were gathered. Similar advantages for boys in boys' schools were not observed.

Girls' schools also differed from coeducational and boys' schools in several important ways. The schools were smaller, operated more days per year, had a lower student-teacher ratio, and had more female teachers as role models. It is also possible that the girls' schools were boarding schools.

While these differences between students and schools were found to contribute to differences in student achievement, a statistically significant residual effect for single-sex schools remained after adjustments were made, suggesting that other organizational or student background factors may account for the observed differences in effects.

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The comparison of single-sex and coeducational schooling has received attention in several recent studies. These two organizational features of schools have been compared in the Catholic secondary sector in America, where approximately half of the schools are single-sex. For both the high school classes of 1982 and 1972, students in single-sex schools were found to evidence higher achievement and higher educational aspirations than their counterparts in coeducational schools.[1] For eighth graders in Thailand in 1982, Jiminez and Lockheed found higher gains in mathematics achievement for girls in single-sex schools, whereas boys fared better in a coeducational school environment.[2] All of these studies found single-sex schooling generally more beneficial for females than for males.

Examining the differential effectiveness of schooling by gender in developing countries is made more difficult, however, by the reality of gender differences in school attendance rates.[3] In many countries, fewer females attend school, sometimes resulting in a relatively more socially and cognitively select group of females in school. The situation is most acute in the non-industrialized countries of East Africa, South Asia, and Southern Europe.[4] Moreover, female participation rates in the lowest income countries decline precipitously between primary and secondary educational levels.[5]

Explanations for lower female participation rates and the decline at the secondary level emphasize the role that female maturation, marriage and

anticipated marriage play in family decisions to remove girls from schooling, particularly in traditional cultures that question the effect of education on the subsequent roles and behaviors of females.[6] Governments in such countries are less willing to invest in educational establishments that are exclusively for young women, except in countries such as Saudi Arabia, where coeducation is culturally unacceptable.[7] Moreover, because of ambivalence about the importance of educating girls, the actual treatment of females in schools in some developing countries has been found to be inferior.[8] While single-sex secondary education could be seen as facilitating female achievement and promoting greater female participation in schooling where the physical safety of adolescents is an issue, the evaluation of the relative effectiveness of coeducation compared to single-sex schooling may be confounded by the fact that more males than females are in school in the first place in developing countries.

Single-sex education may be seen both as an economic and a social issue, in addition to the relatively straightforward question of differential educational effectiveness. A movement away from single-sex education at both the secondary and post-secondary levels, motivated by both social and economic reasons, was experienced in the 1960's and 1970's in the United States. Single-sex education was viewed as a barrier to successful adolescent cross-sex socialization, and the declining demand for single-sex education led to institutions either closing or converting to coeducation in order to stabilize enrollments.[9] This trend occurred at precisely the time that research on American institutions was beginning to document positive effects -- especially for young women -- for single-sex education on students' academic and occupational achievement patterns, self- image, and career

choice.[10] In countries where education systems are still expanding, as in many developing countries, economic factors predominate in advocacy for coeducation.

This paper investigates the effects of single-sex and coeducational schooling on adolescents in the public sector in a developing country's school system. Specifically, we have compared the effects of single-sex and coeducational school organization at the ninth grade in Nigerian public schools, examining whether these effects are different for males and females and whether the effects are sustained once statistical adjustments are introduced for differences in student background, school location, and teaching practices. The study compares the effects of these two school organizational types on students' academic achievement in mathematics and on stereotypic views of mathematics. The data for this study are drawn from the Second International Mathematics Study (SIMS) conducted by the International Association for the Evaluation of Educational Achievement (IEA) in Nigeria during the 1981-82 academic year. The analytic sample for this study consists of 1,012 students in 40 Nigerian 9th grade classes. The IEA design sampled a single class in each school, so that 40 schools are represented, half of them single-sex. The sample was 22.4% female, which is slightly underrepresentative of female secondary school participation in Nigeria.

Background

Research on Single-Sex Tertiary Education

In a summary of the results of a large longitudinal study of more than 200,000 students in over 300 American colleges, Alexander Astin concluded that "Single-sex colleges show a pattern of effects that is almost universally positive" with respect to a large array of academic and pre-professional outcomes.[11] Discussing the finding that effects of single-sex schooling were generally stronger for women than men, Astin speculated that such effects were probably due to the more circumscribed heterosexual activity and to a greater sense of identification and communal feeling when both students and faculty are predominantly of the same sex. Other studies have identified undergraduate education in a women's college as a major explanatory factor for women's career achievement patterns.[12] Why does single-sex education produce beneficial effects for women? According to Tidball and Kistiakowsky, women's colleges convey a sense of being in an environment where there are many other women seriously involved in a variety of academic pursuits. The presence of a high proportion of female faculty is another frequently cited factor.

However, tertiary single-sex education has occurred almost exclusively in the private -- as opposed to public -- sector, and research on its effects has not adjusted results either for the greater affluence of students in private colleges, nor for organizational or resource differences between colleges. Further, it has been suggested that these studies failed to consider the possibly greater career and academic motivation that might also be associated with attendance at private and exclusive American women's colleges.[13]

Research on Single-Sex Secondary Schooling

Non-American Western countries. The majority of research comparing single-sex and coeducational secondary schooling has been conducted outside the United States in developed Western countries.[14] Those studies generally have focussed more on students' attitudes about the social and psychological environments of their schools than on academic attitudes and behaviors, and most of the studies have not measured achievement differences between the two school types. They typically involve small non-random samples of schools, and the data analyses are primarily descriptive. The research generally does not include adjustment for differences in the background characteristics of students who attend coeducational and single-sex schools, and often doesn't consider whether the effects might differ for boys and girls. Many of the studies are dated, probably not reflective of attitude changes about sex roles within the last decade.

Whereas single-sex schools, especially those for girls, were considered to emphasize control and discipline to a greater extent, coeducational schools were found to have a more relaxed and friendlier atmosphere.[15] There is, however, some disagreement about actual academic emphasis between the two school types, with some researchers finding girls' schools to evidence a more academic orientation, while others find no positive relationship between gender grouping and academic orientation.[16] A cross-national study used 1970 IEA data measuring attitudes and achievement in science and reading among 14-year-olds in both single-sex and coeducational schools in the United States and England. While no differences were found between coeducational and a small sample of single-sex schools in the United

States (n = 8), noticeable effects appeared in the British sample, which included 47 single-sex schools. Girls in English coeducational schools showed a decline in science and vocabulary relative to male peers, while girls in single-sex schools excelled in reading and science.[17]

American research. Two recent studies which have focused on American Catholic secondary schools are somewhat stronger than the studies cited above, since the samples of students and schools are large and randomly selected. Lee and Bryk examined a random sample of 75 Catholic schools from the High School and Beyond (HS&B) study, which included longitudinal information on student background, attitudes, behaviors, and achievement.[18] Whether concerning academic achievement, achievement gains, educational aspirations, locus of control, sex role stereotyping, or attitudes and behaviors related to academics, their results indicated that single-sex schools deliver specific advantages, especially to their female students. Analyses included statistical adjustment for student background and contextual differences between schools. Another study compared white students in public schools with Catholic single-sex and coeducational school students. Using the 1972 National Longitudinal Study (NLS) data, positive achievement effects were found for single-sex schools, particularly for girls, with limited statistical controls employed.[19]

The relation between sex-stereotyped attitudes and behaviors and American sex-segregated education has received some research attention. In all these studies, which examined students from first to twelfth grades, girls' school students were found to hold less stereotypic attitudes. These ranged from views on women's roles in society, including the appropriateness of women entering typically male professions, to more favorable attitudes toward

feminism.[20] Girls trained in a single-sex environment were also found to demonstrate lower levels of fear of success and were more likely to exercise leadership roles.[21] No significant single-sex effects for boys were reported in any of these studies.

Developing countries. Although single-sex education is somewhat more common in developing than developed countries, research on gender issues in education in developing countries is considerably more likely to focus on the lower school attendance rates of females than on the differential effectiveness of sex-segregated and coeducational schools. An exception is a recent study comparing the relative advantages of the two types of schools for male and female eighth graders in Thailand, using longitudinal data on mathematics achievement before and after eighth grade.[22] Single-sex schools were found to be more effective for female students, where coeducational schools were more effective for male students. While the longitudinal nature of the data, as well as the econometric two-stage modeling of choice into school and effects of school on achievement, make these findings particularly strong, the fact that most of the single-sex schools were private whereas the coeducational schools were mostly run by the state, however, results in an unavoidable but unfortunate confounding of school grouping and school governance in that study.

In many developing countries, girls are less likely to attend school than boys. This causes a special problem for investigations of the relative effectiveness of single-sex and coeducational schools for the two genders, since those girls who do attend school come from more advantaged homes than boys, with girls more likely to have more educated parents who are members of the emergent professional classes.[23] This was found to be particularly true

in African studies, which focused on both Kenya and Nigeria.[24] Despite the slightly higher socioeconomic backgrounds of girls, their education in some developing countries is adversely affected by prevailing social attitudes which favor the intellectual advancement of males, particularly in coeducational settings. For example, while schools might seek to interest boys in skills that are useful in the labor market, girls are urged into more domestically relevant activities.[25]

A sex-differentiated focus has been described for science and mathematics training in Kenya, where most government secondary schools are single-sex.[26] The result of Kenyan girls' schools receiving less government assistance was lower quality education, especially in mathematics and sci . The study concluded that girls' lower access rates to secondary school, as well as their attendance at under-funded girls only schools, resulted in a female disadvantage in terminal national examinations -- a disadvantage which also affected the university attendance and professional preparation of young Kenyan women. In a case study of a West African girls' boarding school in the early 1970s, its "hidden curriculum" included the socialization of young women for future roles as wives and mothers, whereas most students actually intended to seek fulltime employment after completing their education. While the official government policy in that country was to offer the same educational opportunities to boys and girls, the researcher found that differing social attitudes about the usefulness of educating young women and young men influenced the curriculum.[27]

Nigeria. The small amount of existing empirical evidence on single-sex education in Nigeria is inconc ive. In a descriptive study of the education of Nigerian females in the early 1970s, both attendance rates and

educational quality were reported to differ by region of the country.[28] In the predominantly Moslem north, the government has shown less interest in educating girls. While more girls attended school in southern and western Nigeria, the quality of schooling was reported to be lower than for males, especially in schools which enrolled only girls. The safety of children -- particularly girls -- was certainly a factor in families' decisions to enroll their children in school.[29] This study, from the mid-1960s, reported that a major factor discouraging families and adolescent girls from enrolling in school was fear of pregnancy.[30] In this regard, girls only schools (particularly boarding schools) would be seen as particularly favorable, since both students and faculty are overwhelmingly female. While the social environment of Nigerian girls' schools might be preferable for families with educational aspirations for their female daughters, these schools experience special difficulties in providing quality education, due to high staff turnover, lack of special facilities (e.g., for science), and more difficulty in obtaining well-trained teachers (especially women), and a general scarcity of resources.[31]

Education in Nigeria

Nigeria, a federation of 19 states, is one of the largest countries in Africa, with an estimated population of over 80 million. The education system is commensurately large, with approximately 15 million primary students and 3.5 million secondary students enrolled in 1983. In 1982, it was estimated that 97% of the primary age group and 28% of the secondary age group were enrolled in school. Discrepancies between male and female enrollment rates at the secondary level were apparent, however, with females representing only 26%

of secondary students and only 14% of the 12-17 year old female age cohort enrolled, compared to 42% of same age male cohort.[32/] It is important to note that an apparent steep decline in female participation in secondary education between 1980 and 1982 (from 35% to 26% of total enrollment) is entirely due to a doubling of the male gross enrollment in those two years.

Until 1976, the formal education system consisted of nursery and preschool institutions, primary schools, secondary educational institutions of different kinds and duration, and a variety of different higher education institutions. Primary education was 6 to 7 years in duration, with entry age being 5 or 6. Basic secondary education lasted five years. The National Policy on Education adopted in 1976 introduced a uniform six-year primary education, followed by a 3-year lower secondary and 3-year upper secondary program. As the data analyzed in this paper were collected in 1980-81, students in Form 3 (grade 9) would have attended school under both old and new plans.

It is clear that in Nigeria, as in many developing countries, the educational milieu is changing rapidly. While school enrollment is expanding, the proportion of the school population which is female is not (in fact, it has declined, as noted above). While males and females have been afforded theoretically equal access to education, traditional social attitudes about the appropriateness of education for young Nigerian women are not apt to change so rapidly toward social equality of the sexes. It should, therefore, not be surprising if findings from this study, where data were collected in the early 1980s, are somewhat different from those studies which described Nigerian educational conditions in the 1960s and 1970s. While useful in depicting the particular educational difficulties for females, the historical

research may not depict accurately the educational environment for Nigerian females in the 1980s.

In almost all of the research on single-sex and coeducational schooling in both developed and developing countries, we see a confounding of school governance issues (private vs. public or state-supported schools) with school gender grouping (single-sex vs. coeducational). This is because coeducation is more common in state-supported institutions, whereas single-sex grouping is often a characteristic of privately funded schools. The research in American Catholic schools is, of course, confined to the private sector. Although single-sex schooling exists in the public sector in Australia, Britain, New Zealand, and Canada, the research from those countries typically does not identify school sector -- public or private -- leaving us unable to untangle school governance from school organization as causal factors. The study of Thai schools has sector and school sex grouping totally confounded. However, the study described here investigates the question of single-sex and coeducational school organization exclusively in the Nigerian public educational sector.

Method

Sample and Data

The IEA Nigerian SIMS sample was comprised of 41 mathematics teachers in state-owned Secondary Grammar Schools which prepared students for the West African School Certificate Examination and their 1126 Form 3 students; it was derived from a three-stage, stratified random sampling plan.

The primary sampling units were the ten southern states in Nigeria. Although the target population was originally intended to include students from all states, logistical and financial constraints caused this to be reduced to the 10 southern states, which include 90% of the country's school enrollments. Of these, acceptable data were received from eight states. Within each state, a random sample of schools was selected, with probability proportional to the number of schools in the state. At the second stage, a random sample of one class per school was selected, and at the final stage, about 30 students were randomly selected in each class, or the entire class was sampled if it contained fewer than 30 students.[33/]

Students were administered a mathematics test and a background questionnaire. Teachers completed several questionnaires about their backgrounds, their general classroom processes, their teaching practices, and characteristics of their class. Data about the school were provided by a school administrator. Although a very large number of measures was collected in the IEA study, only those used in this paper are described below.

The analytic sample of students and schools used in this study is described in Table 1. Of the 1,012 students comprising the analytic sample, only 227 (22.4%) are female. About half (51.9%) of the students are in single-sex schools, with more of the males (56.3%) than the females (34.7%) in such schools. This is reflected in the school distribution, which is exactly half single-sex (20 of 40 schools).

Table 1: Number of Students and Schools in the Analytic Sample

Type of School	Number of Schools	Number of Students
Coeducational Schools	20	492
Girls	-	149
Boys	-	343
Single-sex Schools	20	520
Girls	4	78
Boys	16	442
Total	40	1,012

Measures

Mathematics achievement. The mathematics test used as the major dependent variable was the forty-item SIMS "core" test. The curricular content of the SIMS test was decided upon by all country participants in the SIMS study, and items testing this content are constant across countries. The core test contained items covering five curriculum content areas (arithmetic, algebra, geometry, statistics and measurement). The score is total number of correct answers, with no adjustment for guessing.

Student background and attitudes. Student background variables include both conventional demographic measures -- sex, age, rural residence, and paternal occupation (professional or non-professional) -- as well as

indicators of student educational aspirations and attitudes.[34/] The measure of educational aspirations was tapped by the number of years of additional education the student expected to receive. We have also included four attitudinal factors. In constructing these indices, we first conducted exploratory principal component and varimax rotation factor analyses of a 9-item student survey of perceived parental attitudes and a 46-item student attitude survey. Two factors emerged from the perceived parental attitudes survey and five interpretable factors emerged from the student attitude survey. We then conducted confirmatory factor analyses and computed factor scores for each of the seven factors.

This paper reports results from four of these factors: (a) self-perception of ability, (b) perceived parental support, (c) motivation with respect to mathematics, and (d) gender-stereotypic views about mathematics. "Perceived ability" was constructed from four items (e.g., "I could never be a good mathematician") having factor loadings ranging from .68 to .77, and a higher score on this factor indicates a lower perception of one's ability in mathematics. "Perceived parental support" was constructed from four items (e.g., "My parents are interested in helping me with mathematics") having factor loadings ranging from .64 to .79. "Motivation" was constructed from four items, (e.g., "I want to do well in mathematics") having factor loadings ranging from .68 to .81. "Gender stereotypes" was constructed from three items ("Boys have more natural ability in math than girls"; "Boys need more mathematics than girls"; "Men make better scientists and engineers than women") having factor loadings of .86, .82 and .77 respectively; higher scores indicate views of mathematics being more appropriate for males, which we interpret as a more stereotypic attitude.

School characteristics. Data on three school characteristics were analyzed: (a) school size, as indicated by the total number of students enrolled in the school, (b) length of the school year in days, and (c) our major covariate of interest -- single-sex (boys' or girls' school) or coeducational school type. Two characteristics of the classroom are included: (a) student/teacher ratio, and (b) percentage of students in class with fathers in professional occupation (an aggregate of the student responses to this item). Because of the sampling design used, classroom and school characteristics are confounded.

Teachers and teaching. Two teacher background characteristics were analyzed: (a) teaching experience and (b) number of semesters of post-secondary mathematics education studied. Teaching processes involved teachers' reported use of time for administration, instruction, and evaluation, and the time students spend listening to whole-class instruction. These were teachers' self-reports of time use, and no observation data are available for corroboration. "Administrative time" was defined as the number of minutes per week used for routine administration and for maintaining order in the classroom. "Instructional time" was defined as the number of minutes per week used for explaining new material and reviewing old material. "Evaluation time" was defined as the number of minutes per week devoted to testing and grading student work. To test for non-linearity effects of time, we also employed quadratic terms for each of these. Two indicators of use of material inputs are included in this paper: (a) an index of teacher use of commercially produced textbooks and workbooks, and (b) an index of teacher use of personally produced teaching materials. "Opportunity to learn" was defined

as the number of items on the core mathematics test that the teacher claimed to have taught during that school year.

Analysis Approach

Students were divided into four sex-by-school type groups: (a) girls in girls' schools; (b) girls in coeducational schools; (c) boys in boys' schools; and (d) boys in coeducational schools. The two dependent measures examined in the paper are (a) mathematics achievement and (b) stereotypic views of mathematics. We present means and standard deviations (s.d.) of all independent and dependent variables initially included in the two causal analyses examined in the study, and the statistical significance of mean differences between the four groups on each independent measure were tested by one-way analysis of variance (ANOVA).

The analytic sample combined male and female students, with dummy-coded program variables for girls-only and boys-only schools. We employed an analysis of covariance (ANCOVA) analytic design, using the two dummy-coded program variables as covariates. Ordinary least squares regression is the major analytic method used with ANCOVA, allowing the estimation of the two program effects net of other variables in the model. After considerable exploratory work investigating the many variables included in the IEA study, concentrating particularly on classroom and teacher variables which might "explain away" the potentially spurious relationships between school type (single-sex or coeducational) and the two dependent variables, we arrived at the final analytic model.[35/] Effects are presented as both standardized and unstandardized regression coefficients, and the standard errors of the latter are included to indicate statistical

significance levels. We have interpreted the standardized (beta) coefficients as effect sizes. The use of an effect size metric allows comparison of the magnitude of effects between independent variables in a particular model and also across outcomes measured in different metrics.[36/]

We present regression results for both outcomes in two steps. The first step evaluates the effects of attending a boys' school or a girls' school, compared to a coeducational school, after adjustment for characteristics of individual students -- background differences (age, sex, SES) and attitude differences (perceived ability and motivation). In fact, the regression analysis from step 1 constitutes the major evaluation of the relative effectiveness of the two school types. In the second step, which also includes all background and attitudinal characteritics of students, characteristics of schools (rural location, average SES, and student/teacher ratio) and of teachers and teaching (experience, sex, materials, and time usage) are added. The change in the regression coefficients attached to school gender grouping type allows us to examine whether these effect measures might in fact be explained away by including measures which tap the school process itself. In addition, while the focus of the analyses is on the regression coefficient attached to school type, we also discuss the effect of these other school process variables on the two outcomes -- mathematics achievement and stereotypic views of mathematics.

Descriptive Differences Between the 4 Sex-by-School Type Groups

Background. Average differences between students enrolled in single-sex and coeducational schools were pronounced, with both boys and girls in single-sex schools generally more advantaged than their counterparts in

coeducational schools (Table 2). Advantages appeared in terms of family and personal background variables, suggesting the presence of selection effects into schools (despite the fact that all schools in the sample are "government" schools). All differences were statistically significant ($p<.001$). While the four girls' schools were located in urban settings, about a quarter of all other students attended school in rural areas. Although all students were in the same grade (Form 3, or 9th grade), students in single-sex schools, particularly girls, were younger. These girls were about a year younger, on average, than boys and girls in coeducational schools and boys in boys' schools, and fully two years younger than boys in coeducational schools (who at 17 years old, on average, are a year older than boys in boys' schools).[37]

While girls and boys in coeducational schools were equally advantaged in the proportions of fathers following professional occupations (17%), girls' school students were more likely to have professional fathers than boys' school students (34% vs. 23%). However, less than a fifth of all students reported going to school in the language they spoke at home, and this percentage was lower for girls in single-sex schools. There was a bigger

Table 2: Descriptive Characteristics of Girls and Boys in Single-Sex and Coeducational Schools in Nigeria

Variables	Girls in girls' schools	Girls in coed schools	Boys in boys' schools	Boys in coed schools
Family and personal background:				
Age (months)*** a,b	182.15 (15.63)	196.38 (19.77)	194.42 (19.35)	201.66 (21.30)
Father, professional*** occupation	.34 (.48)	.17 (.38)	.23 (.42)	.17 (.37)
Rural residential*** location	.00 (.00)	.25 (.43)	.24 (.43)	.28 (.45)
Speaking language of instruction at home	.14 (.35)	.20 (.40)	.18 (.39)	.18 (.38)
Years more *** education expected	3.49 (0.93)	3.35 (0.98)	3.75 (1.00)	3.58 (1.07)
Attitudes about self and family:				
Perceived ability*** c	3.33 (1.23)	3.56 (1.21)	3.00 (1.15)	3.20 (1.22)
Parental support	3.50 (1.31)	3.64 (1.60)	3.64 (1.48)	3.79 (1.65)
Student motivation***	5.83 (0.60)	5.40 (1.06)	5.84 (0.70)	5.63 (0.85)
School, classroom characteristics:				
School size***	866.17 (117.20)	973.35 (226.92)	1194.40 (428.56)	936.76 (219.77)
Length, school year***	194.90 (9.57)	184.19 (9.83)	188.16 (16.25)	187.43 (9.93)
Stu./teacher ratio***	21.98 (2.54)	29.53 (15.27)	24.80 (7.06)	28.70 (14.00)
Female teachers***	1.00 (.00)	.18 (.39)	.13 (.34)	.16 (.37)
%Students in school w.*** professional fathers	.34 (.47)	.18 (.91)	.18 (.91)	.10 (.30)

Variables	Girls in girls' schools	Girls in coed schools	Boys in boys' schools	Boys in coed schools
Teachers and teaching:				
Years experience***	8.69 (6.20)	4.38 (4.66)	11.94 (11.04)	4.69 (5.08)
Teacher preparation,*** #sem. sec. math ed.	2.35 (0.48)	2.64 (1.44)	4.18 (2.32)	3.38 (1.25)
Time, in minute/week, spent on:				
Administration***	92.54 (85.62)	65.11 (48.95)	78.55 (68.57)	57.98 (51.99)
Instruction***	138.14 (24.60)	97.46 (100.23)	171.85 (137.25)	90.88 (92.41)
Evaluation***	233.91 (23.75)	116.28 (76.99)	189.86 (130.51)	125.60 (79.81)
Whole-class lecturing***	60.06 (33.86)	50.56 (37.47)	33.29 (33.03)	45.57 (31.93)
Use of materials index:				
Commercial texts***	8.35 (0.48)	9.36 (2.06)	8.68 (1.62)	9.27 (1.95)
Personally made***	6.00 (0.00)	5.53 (0.62)	5.36 (1.00)	5.64 (0.58)
Opportunity to learn***	4.83 (6.32)	10.96 (11.95)	11.70 (10.47)	11.62 (11.83)
Outcome Measures:				
Score, math test***	16.12 (5.35)	12.76 (4.99)	14.51 (5.88)	13.87 (6.18)
Stereotypic view*** of math	3.09 (1.42)	3.54 (1.63)	4.84 (1.53)	4.61 (1.72)

Note:
(a) Asterisks indicate significance levels (*=p<.05; **=p<.01; ***=p<.001) for the F-statistic from a one-way analysis of variance of four sex-by-school grouping and each variable.
(b) Standard deviations in parentheses.
(c) Variable coded so that a high score indicates a low self-perception of ability in mathematics.

difference by sex than by school type in educational aspirations, and boys expected to complete more years of schooling; nevertheless, students in single-sex schools reported higher aspirations than those in coeducational schools. This general pattern indicates that single-sex schools, particularly girls' schools, enroll a slightly more select group of students. Given these significant background differences, the necessity for statistical adjustment in our analyses was evident.

Attitudes, school, and classroom differences. The same pattern of apparently greater advantage for students in single-sex schools existed for two of the three attitudes we investigated. While students in single-sex schools reported having higher self-perceptions of their ability in mathematics and greater motivation to do well at mathematics, school type was unrelated to perceived parental support. Single-sex schools in Nigeria, especially girls' schools, were more advantaged than coeducational schools in several other respects: lower student/teacher ratios, more instructional days, and higher proportions of professional fathers (i.e., higher SES). How to interpret the relative differences in average school size is difficult. While larger schools are likely to have access to more resources, smaller schools could induce a more intimate environment, one which might foster a sense of community between students and faculty. We found that all-male schools were the largest, and all-female schools the smallest, with coeducational schools about midway between.[38/] The mathematics classes in the girls' schools were entirely taught by females, whereas less than a fifth of the mathematics teachers in the sampled classes in the other three groups were female. All school and classroom differences were statistically significant ($p<.001$).

Teachers and teaching. All teachers taught mathematics, but teachers in single-sex schools (especially boys' schools) had considerably more teaching experience. Boys in both types of schools were taught by considerably better prepared teachers. Teachers in girls' schools (all females) had the least preparation in mathematics. Teachers in single-sex schools spent more time on administration and instruction. While teachers in girls' schools spent considerably less time in testing and evaluating students, boys' school teachers reported the most time in this activity. We see the opposite pattern for time in lecturing -- girls' school teachers spent the most, and boys' school teachers the least. Teachers in coeducational schools reported more access to commercially made texts and materials, whereas girls' school teachers reported using more materials they prepared themselves than teachers in the other schools. Girls' school teachers reported having taught far fewer concepts on the IEA mathematics test than other teachers, reflecting either (a) non-coverage of a concept, or (b) coverage of the concepts in previous years. All teaching differences were significant below the .001 probability level.

Outcomes. Large unadjusted group differences existed on the mathematics test, with girls' school students scoring almost a full standard deviation above girls in coeducational schools. The latter group scored lowest on this measure. Boys' school students also outscored their male counterparts in coeducational schools, but by only one-tenth of a standard deviation. Gender-related stereotypes about mathematics also differed substantially by school type and gender, with girls in single-sex schools exhibiting the least stereotyping, and boys' school students holding the most gender-stereotyped attitudes. We should not place too

much confidence in these outcome differences favoring girls' schools, however, since we have seen that the students in girls' schools are also advantaged in many aspects of both background, attitudes, school, and teaching characteristics. It is, therefore, essential to employ multivariate methods to adjust for such potential confounding.

Results

Estimating Single-Sex School Effects After Adjusting For Differences in Student Background and Attitudes, Schools, and Teaching Practices.

Math Achievement. The multivariate regression model which examines the net effect of attending either a boys' or a girls' school (compared to a coeducational school) on achievement is presented in Table 3. In Table 2, we demonstrated significant variation by school sex grouping of multiple school process measures. The final model was decided upon both theoretically and analytically. That is, we included each variable from Table 2 in an original model, and then eliminated those without significant relationships with either the single-sex/coeducational contrast or with the outcome variable. Thus, many variables on which there were considerable school type differences in Table 2 (e.g. school size, educational aspirations, opportunity to learn, length of the school year, time on administrative tasks or lecturing) were eliminated from the final model.

Step 1 of the model, which includes adjustments for student background and attitudes, shows that attendance at a girls' school is significantly related to mathematics achievement ($\beta = .14$), while boys'

school attendance is not related (ß = .03). Other student characteristics related to achievement are age (younger students achieve at higher levels), and perceived ability (higher perceived ability is positively related to achievement level, due to the direction of variable). While this analysis shows that girls' school students score higher, the model explains only 5 percent of the variance in mathematics achievement. Note that social class (i.e., student's father has professional job) is not significantly related to mathematics achievement.

Table 3: Estimated Effect of Attending a Single-Sex School on Math Achievement in Nigeria, 1981-1982

	(1)			(2)		
Variable	Beta[a],[b]	Coeff.[c]	S.E.[d]	Beta	Coeff.	S.E.
School sex type:						
Girls' school	.14**	2.72	.88	.12*	2.38	1.03
Boys' school	.03	.35	.48	-.11*	-1.28	.54
Background:						
Age, months	-.08*	-.02	-.01	-.09*	-.03	.01
Sex, female	-.08	-1.13	.66	-.06	-.78	.62
Prof.father	.006	.08	.52	-.03	-.49	.53
Attitudes:						
Perceived ability	-.10**	-.49	-.18	-.09*	-.44	.17
Motivation	.07	.48	.27	.06	.44	.25
Stereotyping,math	-.02	-.08	.18	.01	-.03	.17
School characteristics:						
Rural				.22***	3.18	.61
% Prof.fathers				.14**	5.00	1.75
Stu./teacher ratio				-.12**	-.06	.02

	(1)			(2)		
Variable	Betaa,[b]/	Coeff.[c]/	S.E.[d]/	Beta	Coeff.	S.E.
Teachers, teaching:						
Teacher experience				.06	.04	.03
Teacher sex (female)				.00	.00	.60
Use, published material				-.03	-.10	.15
Time, instructional tasks				-.11*	.01	.00
Time, students listening				-.26***	-.04	.01
Time, administrative tasks				-.07	-.01	.01
Time,admin.,squared[e]/				.14	.00	.00
Constant		17.98			21.65	
R2		.05			.16	

Note:

(a) These are standardized regression coefficients, equivalent to adjusted correlations between the independent variable after having taken the other independent variables in the model into account. We interpret these as effect sizes.

(b) Nominal significance levels of regression coefficients are as follows: *=p,.05; **=p<.01: ***=p<.001. Determined as t-statistics computed by dividing the unstandardized regression coefficient by its standard error.

(c) These are unstandardized regression coefficients.

(d) Standard error of unstandardized regression coefficients.

(e) The relationship between math score and the teacher's time spent on administrative tasks had both linear and quadratic components. This variable represents the quadratic component.

In the final model (step 2), both single-sex school effects are significant, albeit in opposite directions (ß = .12 for girls' schools, ß = -.11 for boys' schools). That is, girls who attend single-sex schools are significantly more likely to evidence higher achievement in mathematics than their female counterparts attending coeducational schools. On the other hand, boys who attend single-sex schools score significantly below their male coeducational school counterparts. These results hold after the considerable differences in background, attitudes, schools, and teaching have been statistically equated across these schools.

In addition to school sex grouping, other significant predictors of mathematics achievement are, again, age and perceived ability. Three school-level factors are strongly and positively associated with higher mathematics achievement: (a) rural location; (b) schools with a higher proportion of fathers in professional jobs (i.e., higher-SES schools); and (c) schools with lower ratios of students to teachers (i.e., smaller classes). Two measures tapping teachers' time use are significantly and negatively related to mathematics achievement. This indicates that less time spent by teachers on whole class instruction (introducing new material and reviewing old material) and by students listening to teacher lectures would induce higher achievement in mathematics. The final model explains 16 percent of the variance in mathematics achievement.

A few non-significant relationships in this model are noteworthy.[39/] The most important "no difference" finding is for sex. That is, there is no significant difference between the mathematics scores of Nigerian adolescent girls and boys, once the other variables in the model (including type of school attended) are taken into account. Similarly, there is no relationship

between mathematics achievement and the sex of the mathematics teacher. In addition, neither student motivation, stereotypic attitudes about mathematics, nor teacher experience appear to influence mathematics achievement. In theory, it seems likely that these variables would be related.

Stereotypic views of mathematics. The regression model which investigates the relationship between single-sex schooling and students' stereotypic attitudes about mathematics is presented in Table 4. As the single-sex school effect in step 1 of Table 3 was not "explained" away by school process variables in step 2 of the analysis, we have presented Table 4 as a single-step regression. A different, and smaller, set of confounding variables is included in this model than in the previous analysis. This model was developed with the process described earlier. While the final model is smaller than that for mathematics achievement, it explains somewhat more (24 percent) of the variance. We interpret a lower score on this dependent measure as preferable to a higher score (i.e. less vs. more stereotypic views of mathematics). The favorable pattern of effects for attending single-sex schools is the same as that shown for mathematics achievement: girls' schools appear to instill in their students less stereotypic views of mathematics as a male domain than do their coeducational school counterparts (β = -.10), whereas boys' schools seem to foster more stereotypic views in their male students than do coeducational schools (β = .08).

The relationships of other predictors varies considerably from the achievement model. Even after holding constant the school types which are our major focus, we see that girls in both sorts of schools hold very significantly less stereotypic views of mathematics than do boys (β = -.35). Since the definition of the variable typifying "stereotypic views" favors

males over females, such a finding is not surprising.[40/] In addition, higher SES (ß = -.06), typified by the professional position of fathers, is associated with less stereotypic views, where it was not related to achievement. Rather more surprising is the significant and positive association of student motivation, also unrelated to achievement, to stereotyping (B = .16). As before, some "no association" findings are noted. First, ability in mathematics,

Table 4: Effect of Attending a Single-Sex School on Stereotypic View of Mathematics in Nigeria, 1981-82

Variable	Beta Coefficient[a,b]	Regression Coefficient[c]	Standard Error
School sex type:			
Girls' school	-.10*	-.46	.21
Boys' school	.08*	.21	.09
Background:			
Sex, female	-.35***	-1.08	.12
Prof.father	-.06*	-.20	.10
Test score	-.03	-.01	.10
Attitudes:			
Motivation	.16***	.26	.05
Teachers, teaching:			
Teacher sex (female)	.02	.06	.11
Time, evaluation	-.07	-.00	.00
Time,eval.,square[d]	.04	.00	.00
Constant		3.35	
R2		.24	

Note:

(a) These are standardized regression coefficients, equivalent to adjusted correlations between the independent variable after having taken the other independent variables in the model into account. We interpret these as effect sizes.

(b) Nominal significance levels of regression coefficients are as follows: *=p<.05; **=p<.01: ***=p<.001. Determined as t-statistics computed by dividing the unstandardized regression coefficient by its standard error.

(c) These are unstandardized regression coefficients.

(d) The relationship between stereotypic view of math and the teacher's time spent on monitoring and evaluation had both linear and quadratic components. This variable represents the quadratic component.

represented here by score on the IEA mathematics test ("test score"), is not statistically associated with stereotyping. Second, the sex of the teacher appears to have no effect on mathematics stereotyping views of students in the math class, even though the sex of the student is a very strong factor in such attitudes. This lack of relationship may be due to the fact that, except in our sample of girls' schools (where all the mathematics teachers were females), the other three sex-by-school types were equally likely (or unlikely) to have female mathematics teachers.

Discussion

Single-Sex School Effects

Summary of findings. The findings indicate that single-sex schools affect Nigerian girls positively in both increasing mathematics achievement and engendering less stereotypic views of mathematics. This suggests that such schools have a powerful and positive effect on their female students. In light of earlier research on education in Nigeria which suggested both that girls generally were less educationally advantaged, and that single-sex schools were particularly likely to experience lack of resources which may have contributed to that disadvantage, it is gratifying to find that the girls' schools in this sample appear to have a powerful and positive effect on the educational experiences of their constituents. While the female students in either type of school represent a small proportion of the age-appropriate cohort of potential students, girls attending girls' schools appear to experience particular benefits as a result.

On the other hand, single-sex education appears to have less positive effects on Nigerian adolescent males, where the students experience lower mathematics achievement and hold more stereotypic views of mathematics. These findings about single-sex education, therefore, resemble those reported in the Thailand study more than the findings of the study of American Catholic high schools[41] . Although many of studies which examine the effects of single-sex education have found more positive effects for girls' than boys' schools (especially in developed countries), only two studies in developing countries (this study and the Thai study) have found that boys' schools had negative effects on their students. Therefore, it should not be concluded from this study that single-sex schooling is more beneficial to students than coeducation; rather, it seems to be particularly effective for females.

Possible explanations for findings. Why might this be the case? Although this study was designed to evaluate the relative effectiveness of the two types of schools for male and female adolescent students in Nigeria, rather than to describe the internal workings of schools, we can hypothesize possible explanations for such findings from the school descriptors included here. The relative sizes of the schools is suggestive. Girls' schools have the smallest, and boys' schools the largest enrollments. As mentioned above, larger school size may be see as either an advantage or a disadvantage. It may be that the more intimate environment of smaller schools overshadows the disadvantage accruing from fewer resources, producing an environment where student learning is fostered. This may be also reflected in smaller student/teacher ratios in girls schools (although those in the larger boys' schools are not corresponding larger). Time usage is also suggestive, since girls' schools report spending most time on lecturing and least on evaluation,

whereas boys' schools report the opposite pattern. Of course, these factors were included in the initial analyses, but statistical adjustments may not wholly trap the full result of school size and time differences.

Another advantage for girls' only schools relates to the matching of the genders of teachers and students. In the girls' schools in this sample, all teachers in the sampled math classes were female, which may foster a symbiotic and supportive relationship between female staff and students. Girls in Nigeria single-sex schools may be inspired to academic excellence by female role models they see every day. While girls' school students see only women mathematics teachers, the girls in coeducational schools are in contact with only a small number of such females, as the mathematics staffs of their schools are less than 20 percent female. The role model aspect of mostly male teachers in all-male schools possibly makes less of an impact, since these boys live in a society which has males dominant in all professional roles.

Other possible explanations for the findings of this study relate to issues of selectivity which, in a study such as this, is both a statistical nuisance and a social phenomenon. Other research describing educational conditions in developing countries (particularly in Africa) has reported lower attendance rates for females, often resulting in higher social status for in-school females. While girls in coeducational schools in this study were no more likely to have professional fathers than their male coeducational counterparts, girls' school students more frequently reported professionally employed fathers. Although we have statistically adjusted for this SES difference -- both for individual students and with the aggregate measure for schools -- it is always likely that girls in single-sex schools are socially advantaged in other ways not measured in the IEA study. The fact that girls'

school students are at least a year younger than the other three groups would indicate that these girls had few interruptions in their school careers, or were less likely to have repeated a grade, or both. Since non-rural residential location was totally confounded with girls' school status, it is also possible that this particular residential status somehow favored these girls in ways not included in the statistical adjustment for this difference.

Although all the schools in this study were government-run, it is also possible that some of the schools -- possibly all the girls' schools -- were boarding schools, an important school characteristic not measured in the IEA survey. Such an uninterrupted effect of school on students in a boarding environment could be particularly favorable for cognitive development. Another unavoidable analytic difficulty in the study results from the fact that there were only four girls' schools in the study (and 78 students), whereas the other school groups were more numerous. While this is not a serious statistical problem (with analysis at the student level), random selection is always less likely to produce representative samples when school samples are small. That is, the four girls' schools in this study may be special in some way not tapped by the measures we have included. On the other hand, the sixteen boys' schools could also be different. While there is no particular reason to suspect sampling bias in one direction or another, we mention this possibility.

Education of Females

Since secondary school participation rates for females are so much lower than for males in developing countries like Nigeria, both educational officials and educational researchers should pay special attention to those

school-level factors which are shown to promote positive attitudes and achievement especially for female students. In Nigeria, boys seem to benefit from sharing their school experiences with females, while females are benefited by excluding males from their primary educational environment. Perhaps Nigerian boys' schools should be examined more closely for particular curricular or organizational structures which might impede their students, rather than suggesting that single-sex education for young men be curtailed in Nigeria. Unfortunately, the IEA study was short on details about school organization.

As mentioned earlier, the threat of physical abuse, rape, and pregnancy are seen as particular barriers which discourage school attendance for females who have reached the age of puberty in some developing countries. Certainly such threats are minimized in schools with a faculty and student body that are primarily female. It could be the case that girls' schools are seen as safe and orderly environments where learning may be the primary focus of a young woman's life, without the distraction of potentially disruptive social encounters. Under that view, the small number of Nigerian females in single-sex schools is regrettable, for both in methodological and substantive reasons.[42/]

Of course, parental concerns for safety could be met by other forms of re- structuring education: employing more female teachers and administrators in coeducational schools; building additional local secondary schools instead of requiring parents to send their daughters to coeducational secondary boarding schools (in which other students, teachers, and administrators were male), developing high quality correspondence courses for

secondary school equivalency; using radio, television and other distance learning techniques to make education available to girls in their homes.

Even more important, in our opinion, is the fact that we were able in this study to identify factors influencing the educational experiences of young women in Nigeria, rather than (as has dominated past research on gender issues in education in developing countries) focusing on factors which encourage school participation. What happens to young women after they get to school is surely important in their (and their families') decision to send them to school in the first place or to encourage their persistence, and could be as big a factor in that decision as the commonly cited conditions of the presence or proximity of schooling.[43/] These latter factors are related more to young girls' school attendance but less to persistence in the educational process for those who chose to enter in the elementary years. Identifying particular school conditions which encourage females to continue their education to the end of secondary school (or even to the university), however, has received little research attention. This study suggests that education in a single-sex environment is very likely to be associated with persistence in school for young Nigerian women, since it is related to both school success and less stereotypic views of female roles. We would like to see research which examines the educational experiences of students in developing countries begin to focus on those experiences which have particularly strong effects on the educational success of females, beyond simply attending school in the first place.

Sex Differences in Mathematics Achievement

The investigation of gender differences in mathematics achievement is a popular research topic. Such research has generally concluded that secondary-level females score considerably below their male counterparts in achievement in mathematics, while few differences are observed before Grade 8.[44] Explanations for these differences range from genetic to environmental.[45] Environmental explanations include differential coursetaking in mathematics among college-bound high school students, differential within-class socialization experiences, and differential attitudes toward the usefulness and gender-appropriateness of mathematics. Genetic explanations center on spatial visualization "deficits" in females.

Almost all of the research on gender and mathematics has centered on American students, however. At the very least, research on the topic has been confined to developed countries.[46] However, in this study we have found that girls outscore boys in mathematical achievement in Nigerian schools, and a similar study using IEA mathematics achievement data in Thailand showed females' mathematics achievement superior to that of males before statistical adjustment.[47] After statistical adjustment for the differences between the types of students who attend different types of Nigerian schools (Table 3), there remained only a small and statistically non-significant sex difference in mathematics achievement favoring males. This is particularly noteworthy, since the average age of these Nigerian students (between 15 and 17 years old) is about the same at which the maximum sex differences in mathematics achievement are seen in American adolescents.

Lockheed and her colleauges have argued that one important feature of American pre-secondary education, in comparison with secondary and

post-secondary education, is the absence of student choice in curriculum decisions, and that curricular uniformity may account for the absence of sex differences in mathematics performance before the secondary level.[48] With national or state-level curricula in place in most schools in developing countries, curricular uniformity is the rule, rather than the exception. Girls, therefore, will be exposed to the same content as boys, and choice will not have any part to play in determining the nature of that experience. Therefore, potential socialization of females against mathematics may not be manifested behaviorally in taking fewer courses.

Another possible explanation for the absence of sex differences in mathematics achievement in this study concerns the relative selectivity of the female sample. As mentioned earlier, low female school attendance in Nigeria is likely to result in a more select group of females than males in Nigerian secondary schools. However, the lack of a gender difference in mathematics achievement after adjustment for (a) single-sex or coeducational school attendance, (b) social class and other student background and attitudinal characteristics, and (c) school and teaching differences is evidence that a sex difference favoring males is not the case in Nigeria. None of the American research cited was able to "explain away" large and statistically significant sex differences in secondary-level mathematics achievement favoring males, regardless of the variables in analytic models. However, female "inferiority" in mathematics does not appear to exist for Nigerian adolescents, even in a country in which traditional sex-roles for educated females are assumed.[49] Such findings appear to undercut the genetic explanation for female deficits in mathematics. They also suggest that cross-cultural research on this topic is needed.

At the very least, the findings from this study show that something important is occurring in single-sex schools for girls in Nigeria. Such schools appear to facilitate the mathematics development of their female students, in terms of both achievement and attitudes toward the appropriateness of mathematics study. Single-sex schools for boys, however, appear to have the opposite effect. While the nature of the educational process within schools grouped by gender deserves more scrutiny, characteristics of the schooling process in Nigeria which can be shown to positively effect the educational progress of female students are important to document, in our opinion.

A secondary finding from the study which we believe deserves notice is the lack of a sex difference in mathematics for Nigerian adolescents. Given the strong and persistent findings which favor American males in mathematics achievement, the fact that such a "female deficit" is not generalizable to Nigerian young women is noteworthy.

1/ V.E. Lee and A.S. Bryk. "Effects of Single-Sex Secondary Schools on Student Achievement and Attitudes." Journal of Educational Psychology, 78(5) (1986): 381-395; and C. Riordan. "Public and Catholic Schooling: The Effects of Gender Context Policy." American Journal of Education 5 (1985):518-540.

2/ E. Jimenez and M.E. Lockheed. "The Relative Effectiveness of Single-Sex and Coeducational Schools in Thailand." Educational Evaluation and Policy Analysis 11 (summer 1989).

3/The focus of research related to primary and secondary education for females differs sharply between developed and developing countries. In developed countries, where primary education is generally universal, and secondary education participation is quantitatively equal for both male and female students, research has typically sought to explain gender differences in achievement and gender differences in selection of courses of study. (For recent reviews, see M.E. Lockheed, M. Thorpe, J. Brooks-Gunn, P. Casserly and A. McAloon. Sex and Ethnic Differences in Middle-School Mathematics, Science, and Computer Science: What Do We Know? (Princeton, NJ: Educational Testing Service, 1985) and S.S. Klein (Ed.) Handbook for Achieving Sex Equity Through Education. (Baltimore: Johns Hopkins University Press, 1985). In developing countries, by comparison, research has sought to explain gender differences in school participation: enrollment, retention, and completion. Research from developing countries on factors contributing to gender differences in achievement is almost non-existent. For example, a recent annotated bibliography of 52 studies dealing with female primary education identified only 14 studies that were principally concerned with female students, only two of which dealt with learning outcomes. See N. Stromquist. School-Related Determinants of Female Primary School Participation and Achievement in Developing Countries: An Annotated Bibliography. EDT Discussion Paper No. 83. (Washington, DC: The World Bank, Education and Training Department, 1987).

4/ R.L. Strang. Women, a World Survey. (Washington, DC: World Priorities, 1985); R. Horn and A.M. Arriagada. The Educational Attainment of the World's Population: Three Decades of Progress. EDT Discussion Paper No.37. (Washington, D.C.: The World Bank, Education and Training Department, 1986).

5/ A.G. Komenan. World Education Indicators: An Annex to "Improving the Efficiency of Education in Developing Countries. EDT Discussion Paper No. 88. (Washington, DC: The World Bank, Education and Training Department, 1987).

6/ C.A. Anderson and M.J. Bowman (Eds.) Education and Economic Development. (Chicago: Aldine, 1965); and M.J. Bowman and C.A. Anderson. "The Participation of Women in Education in the Third World." In G. P. Kelly and C. M. Elliott (Eds.) Women's Education in the Third World: Comparative Perspectives (Albany, N Y: State University of New York Press, 1982), pp. 11-39.

7/ R. Al-Hariri, "Islam's Point of View on Women's Education in Saudi Arabia." Comparative Education, 23(1) (1987), pp.51-57.

8/ E. Boserup. Women's Role in Economic Development (London: George Allen & Unwin, Ltd., 1970).

9/ A.W. Astin. Four Critical Years: Effects of College on Beliefs, Attitudes, and Knowledge (San Francisco: Jossey-Bass, 1977); J.H. Block. Sex Role Identity and Ego Development. Chapter 7: "Gender Differences and Implications for Educational Policy" (San Francisco: Jossey-Bass, 1984), pp.207-252; and S. Hyde. "The Case for Coeducation." The Independent School Bulletin. 31 (1971):20-24.

10/ Astin; W.T. Furniss and P.A.Graham (Eds.). Women in Higher Education. (Washington: American Council on Education, 1974); P.A. Graham. Women in Higher Education: A Biographical Inquiry. New York: Barnard College, Columbia University. Document Resume. (ERIC Document Reproduction Service No. ED 095 742, 1974); P.A. Graham. "Women Academe." Science, 69(1970):1284-1290; M.E. Tidball and V. Kistiakowsky. "Baccalaureate Origins of American Scientists and Scholars." Science, 193 (1976):646-652.

11/ Astin, p. 41.

12/ Graham (1970, 1974); M.J. Oates and S. Williamson. "Women's Colleges and Women Achievers." Signs: Journal of Women in Culture and Society, 3 (978):-795-806; M.E. Tidball. "Women's Colleges and Women Achievers Revisited." Signs: Journal of Women in Culture and Society, 5 (1980):504-515; and Tidball and Kistiakowsky.

13/ Block.

14/ For research in the United Kingdom, see R.R. Dale. Mixed or Single-Sex school? Volume III: Attainment, Attitudes and Overview; Mixed or Single-Sex School? Volume II: Some Social Aspects; Mixed or Single-Sex School? Volume I: A Research Study About Pupil-Teacher Relationships (London: Routledge & Kagan Paul, Ltd., 1974, 1971, and 1969); and R.R. Dale and P.M. Miller. "The Academic Progress of University Students from Coeducational and Single-Sex schools." British Journal of Educational Psychology, 42 (1972):317-319. For research in Australia, see P. Carpenter. "Single-Sex Schooling and Girls' Academic Achievements." Australian and New Zealand Journal of Sociology, 21(3) (1985): 456-472; P. Carpenter and M. Hayden. "Girls' Academic Achievements: Single-Sex Versus Coeducational Schools in Australia." Sociology of Education, 60(3) (1987): 156-167; and N.T. Feather. "Coeducation, Values, and Satisfaction with School." Journal of Educational Psychology, 66 (1974):9-15. Comparing U.S. and British schools, see J.D. Finn. "Sex Differences in Educational Outcomes: A Cross-National Study." Sex Roles, 6 (1980):9-25. Research on single-sex schools in New Zealand is described by J.C. Jones, J. Shallcross and C.L. Dennis. (1972). "Coeducation and Adolescent Values." Journal of Educational Psychology, 63(1972):334-341. Canadian research is

found in F.W. Schneider and L.M. Coutts. "The High School Environment: A Comparison of Coeducational and Single-Sex Schools." Journal of Educational Psychology, 74 (1982):898-906.

15/ Dale; Feather; Jones, et al.; and Schneider and Coutts.

16/ Studies by Jones, et al. and by E.J. Trickett, J.J. Castro, P.K. Tricket, and P. Shaffner ["The Independent School Experience: Aspects of the Normative Environments of Single-Sex and Coeducational Secondary Schools." Journal of Educational Psychology, 74 (1982):374-381] show a more academic orientation, whreas those by Dale and by Feather find no relationship.

17/ Finn.

18/ Lee and Bryk.

19/ Riordan.

20/ Bryk and Lee; Trickett, et al.; E.L. Vockell and S. Lobonc. "Sex-Role Stereotyping by High School Females in Science." Journal of Research in Science Teaching, 18 (1981):209-219.

21/ M.E. Lockheed. The Modification of Female Leadership Behavior in the Presence of Males. (Princeton, NJ: Educational Testing Service, 1976); E. Price and R. Rosemier. "Some Cognitive and Affective Outcomes of Same-Sex Versus Coeducational Grouping in the First Grade." Journal of Experimental Education, 40(4) (1972):70-77; and R. Winchel, D. Fenner and P. Shaver. "Impact of Coeducation on 'Fear of Success' Imagery Expressed by Male and Female High School Students." Journal of Educational Psychology, 66 (1974):726-730.

22/ Jimenez and Lockheed.

23/ Anderson and Bowman; Bowman and Anderson.

24/ Boserup; G.S. Eshiwani. A Study of Women's Access to Higher Education in Kenya With a Special Reference to Mathematics and Science Education (Nairobi, Kenya: Kenyatta University College. Bureau of Educational Research, 1983); R.H.L. Feldman. "The Relationship of School, Grade, and Sex to Traditional-Modern Attitudes among Gusii Students in Kenya." The Journal of Social Psychology, 96 (1975):135-136; and E.F. Muckenhirn. Secondary Education and Girls in Western Nigeria. (Unpublished doctoral dissertation, The University of Michigan, Ann Arbor, 1966).

25/ Boserup.

26/Eshiwani.

27/ V. Masemann. "The 'Hidden curriculum' of a West African Girls' Boarding School." Canadian Journal of African Studies, 8 (1974):479-494.

28/ Daphne Glazer. "Problems of the Education of Girls in Nigeria." Aspects of Education, 19, 33-42.

29/ While there is little empirical evidence regarding unsafe schools, anecdotal evidence abounds. Deble (1980, p. 89) notes that "many people still hesitate to trust the school where girls are concerned" [I. Deble. The School Education of Girls (Paris: UNESCO, 1980), p. 89]. Lycette cites a recent survey of rural households in India that found about one-fifth of girls were withdrawn from school at the onset of puberty, often because parents felt it was dangerous for an unmarried girl to be in public [M.A. Lycette. Improving Basic Educational Opportunities for Women in Developing Countries (Washington, DC: International Center for Research on Women, 1986)]. The danger is, not surprisingly, sexual in nature. For example, a study of factors affecting repetition and dropout in Papua New Guinea identified "rape and [sexual] coercion" as a major fear of parents about sending daughters to school [L. Yeoman. Universal Primary Education: Factors Affecting the Enrollment and Retention of Girls in Papua New Guinea Community Schools. (Paper presented at the UNESCO Regional Review Meeting, Bangkok, Thailand, November 1985)].

30/ Muckenhirn.

31/ Glazer.

32/UNESCO Statistical Yearbook. (Paris: UNESCO, 1986).

33/ R.A. Garden. Second IEA Mathematics Study Sampling Report (Urbana: University of Illinois, 1984).

34/ While we recognize that paternal occupation, coded dichotomously, is a rather weak measure of socioeconomic status (SES), this was the only SES measure agreed upon for inclusion by IEA participants. Given the lower proportions of girls in school in Nigeria and in this study, and the fact that researchers have found that girls in school in developing countries are likely to come from more advantaged families (although these data do not show higher proportions of females with professionally employed fathers), we admit that the social background of students may be underadjusted in these analyses. We have no reason, however, to suspect that the underadjustment is different for boys than girls.

35/ As the investigation is framed as an analysis of covariance, the homogeneity of regression slopes was tested. The interaction terms between school sex group and other covariates were not significant as a regression step. Since the estimation of unbiased program effects with ANCOVA rigorously assumes parallel relationships of covariates and outcomes across all levels of the confounding variables, interactions between confounding factors and the school-type variables were examined and found to be non-significant as a regression step. See S. Anderson, A. Auguier, W.W. Hauch, D. Oakes, W.

Vandaele, and H.I. Weisberg. Statistical Methods for Comparative Studies: Techniques for Bias Reduction (New York: Wiley, 1980).

36/ R.J. Light and D.B. Pillemer. Summing Up. (Cambridge: Harvard University Press, 1984).

37/ While age is normally positively related to learning, overage students frequently achieve at lower levels, reflecting both later age at entry and grade repetition. We have no information on previous schooling, however.

38/ A similar pattern was seen by Lee & Bryk for American Catholic high schools.

39/ The sample size is sufficiently large to rule out the probability of high Type II error rates, which would spuriously lead to no-effect findings.

40/ As this is a secondary analysis, we had no control over the original questionnaire items in the IEA survey. However, we believe that there might be some natural bias against females at the outset in the items constituting this factor ("Boys have more natural ability in math than girls"; "Boys need more mathematics than girls"; "Men make better scientists and engineers than women"). It does not seem surprising that female students would strongly disagree with these statements.

41/ See Jimenez and Lockheed for the Thai study; Lee and Bryk for the Catholic school study.

42/ We are aware of the fact that the hierarchical nature of these data (i.e. students nested in classrooms/schools suggests that an appropriate method of estimating the effects of schools on individuals is to use a statistical method which takes this structure into effect. However, the small size of the school sample (n=40), and the particularly small number of girls' schools (n=4) made the use of HLM problematic in this instance.

43/ In this paper, we are concerned with those school characteristics that differentially effect the achievement of girls and boys. Textbooks and other school quality inputs are assumed to have equivalent effects on students of both sexes, and are therefore irrelevant to this discussion.

44/ J. Armstrong. "Achievement and Participation of Women in Mathemathics: Results of Two National Surveys." Journal for Research in Mathematics Education, 12(5) (1981): 356-372; C.P. Benbow and J.C. Stanley. "Sex Differences in Mathematical Ability: Fact or Artifact?" Science, 210 (1980):1252-1264; Educational Testing Service. National College-Bound Seniors. (Princeton, NJ: Author, 1984); E. Fennema and J. Sherman. "Sex-Related Differences in Mathematics Achievement, Spatial Visualization, and Affective Factors." American Educational Research Journal, 14 (1977):51-71; A.M. Pallas and K.L. Alexander. "Sex Differences in Quantitative SAT Performance: New Evidence on the Differential Coursework Hypothesis." American Educational Research Journal, 20(2) (1983):165-182; Lockheed, et al.

45/ See Benbow and Stanley for the genetic explanations. See L. Brush [Encouraging Girls in Mathematics: The Problem and the Solution (Cambridge, MA: Abt Books, 1980)]; Pallas and Alexander; and J. Sherman and E. Fennema ["The Study of Mathematics by High School Girls and Boys: Related Variables." American Educational Research Journal, 14(2) (1972):159-168] for environmental explanations.

46/ See S. Walker and L. Barton (Eds.) [Gender, Class, and Education. (Barcombe, Lewes, Sussex (UK): Falmer, 1983)] and J. White, R. Deem, L. Kant and M. Cruickshank (Eds.) [Girl Friendly Schooling. (London: Methuen, 1985)] in Britain, for example.

47/ Since Jimenez and Lockheed analyzed their data separately by sex, it is not possible to compute the sex differences after the considerable statistical adjustments introduced for school selection.

48/ Lockheed, et al.

49/ See Buchi Emecheta. Double Yoke (1982) for a poignant account of female gender-socialization in Nigeria.

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